Problem-Based Instructional Units
for
Physical Science

Lunar Outpost Site:

Rover and Robotics

Lunar Testing Facility

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Title: Lunar Testing Facility

Educator Section

Materials:

- Student Handouts
- Lunar Testing Facility Construction supplies:
  - Foam board
  - Sand paper sheets of different grits
  - Metric Measuring stick
  - Exacto knife
  - Markers
  - Steel Ruler
  - Packing Tape
  - Eye bolt
  - Protractor
  - Wooden slats
  - Cord

Grade Level:
6^{th}-8^{th} grade

Connections to Curriculum:
Science, mathematics, technology

Science Process Skills:
Scientific Inquiry

Science Content:
Science: Forces and Motion

Lesson Duration:
Two or three class periods
One class period presenting the student solutions

Essential Question

What would be the best design for a Lunar Testing Facility to test and measure the forces and motion of a student produced lunar rover?

National Educational Standards

Science

Forces and Motions

1. The motion of an object can be described by its position, direction of motion, and speed. That motion can be measured and represented on a graph.

   Learning Objective:

1.1 The students will use the distance formula to measure the motion of their rover.

2. An object that is not being subjected to a force will continue to move at a constant speed and in a straight line.

   Learning Objective:
   2.1 The students will measure the force of the rover with a spring scale.

3. If more than one force acts on an object along a straight line, then the forces will reinforce or cancel one another, depending on their direction and magnitude. Unbalanced forces will cause changes in the speed or direction of an object's motion.

   Learning Objective:
   3.1 The students will test the best surface for the rover to travel?
   3.2 The students will collect data describing the best angle for their rover to climb up a wall of a crater.

Scientific Inquiry

4. Use appropriate tools and techniques to gather, analyze, and interpret data

   Learning Objective:
   4.1 The students will design a testing facility that will allow the students to gather data describing the forces and motions of their lunar rover.

Lunar Testing Facility

The Lunar Testing Facility (LTF) provides the students an opportunity to design and test their lunar rovers. As the student rovers traverse through a lunar-like environment, the Lunar Testing Facility (LTF) establishes an environment where students can collect data describing the forces and motions exhibited by the rover. The LTF becomes the control group in the scientific inquiry of the forces and motion investigations. All students can gather their data in the same manner and compare their data between the student groups.

The LTF can be constructed by groups of students so that each small group of students would have their own testing facility. The teacher could also construct one Lunar Testing Facility that could be used by all of the students in the class. The LTF could be made from materials readily available in the classroom or can be purchased local craft stores. Foam board offers stability and is a relatively easy material to use. However, a safety concern exists in using an exacto knife and steel rulers to cut the pieces. To overcome this safety concern, pieces of form board could be precut for the students.

The purpose of the Lunar Testing Facility is to test the rovers in a simulated lunar environment for the classroom. The testing facility would need to have the following characteristics:

1. A testing track with inter-changeable surfaces to measure speed, distance, and time.
2. A crater with adjustable sides (inclined plane) to determine the best angle the rover can safely climb.
3. A measurement devise to identify the force exerted by the rover as it travels over the simulated lunar surface.
4. A sand pit to test the student rovers' performance in simulated lunar soil.

Lunar Test Track (Area 1)

One component of the Lunar Testing Facility is the Lunar Test Track. The purpose of this facility is to test the speed and distance the rovers can travel in an environment that is different from a smooth surface. The test track can be two meters long and have inter-changeable surfaces. Different grits of sandpaper would represent

different lunar surface conditions. A two meter speed track can be constructed with one lane.

Materials

1. Foam board
2. Exacto Knife
3. Steel Ruler
4. Pens and pencils
5. Packing tape
6. Various grits of sandpaper

Procedures:

1. Cut the foam board with an exacto knife and a steel ruler. Measure the foam board strips and score them with the knife and the ruler. Cut three foam board strips to 5cm wide and the length of the foam board. Then cut three additional foam board strips to measure 11cm wide and the length of the foam board.
2. Connect the strips together with packing tape. The 11cm wide strips will be the base of the track. The 5cm wide strips will be attached to the base and serve as the walls of the track.
3. Piece the foam board walls and base together to form the track measuring 2.5 meters long.
4. With a meter stick, measure 250cm from the edge and make a mark to represent a starting line. The extra length will allow the rover to get up to speed as it begins its journey along the track.

5. With the meter stick, measure the two meter track and make a mark to serve as the finish line. The extra length beyond the finish line will serve as the area to slow down the rover.

The adjustable surfaces are an important component to the LTF. The idea behind the race track is to have the students measure the speed and the time their rover travels against a know distance or two meters. The students would then use the speed, distance, and time formula to determine the speed. The speed can vary with different surfaces. The surfaces of the track can be changed to determine the effect of the surface and the speed of the rover.

1. Cut strips of foam board 10cm wide.
2. Tape the strips together to measure the same distance as the track.
3. Attach different surface types to the foam board inserts. Different types of sandpaper grits can serve as a variable surface type. Surfaces can be made smooth, rough, and rocky depending on the extent of the testing. Students may want to find the surface that is the fastest for their rover and the surface where the rover is the slowest. Any number of surfaces can be interchanged to represent several lunar conditions.

Mount the race track on a large board that could be located in the center of the classroom. Another option is to make a race track for each group of students to use to test their rovers.

Crater Construction (Area 2)

Craters are the dominate feature located on the moon. Rovers will be asked to climb the crater walls while gathering information about the soil and the lunar surface. In this portion of the Lunar Testing Facility, the rover can be tested for both speed in climbing the crater wall and the angle of the crater wall. Adjustable sides and adjustable surfaces will provide two variables for the students to use for their lunar rover tests. The sides of a crater can be demonstrated as an incline plane. To provide adjustable sides, the model can be made from several boxes of various heights. The boxes can be decorated to represent the moon's crater. To collect a variety of data, the students can use three different sized boxes including high, medium, or low. The angle of the included plane (the wooden slats or strips of foam board) leaned up against the craters would be measured and recorded on the student's data charts. Adjustable surfaces for the sides of the lunar crater can be represented by different grits of sand paper glued to the wooden slats or foam board. Three surfaces would represent a smooth surface, a medium surface, and a rough surface.

Materials:

1. Various sizes of boxes
2. Wooden slats or strips of foam board to use as walls of the crater.
3. Protractor

Procedure:

1. In craft stores, various sizes of boxes can be purchased to represent the craters of the moon. Mount the boxes on a foam board platform to make them secure from the movement of the rovers climbing the crater sides.

2. Adjustable surface slats can be made to represent the sides of the crater. The slats can be made from wooden slats purchased form a craft store or cut from foam board. The slats would need to measure 11cm wide X 40 cm long.
3. Each set of slats can have a variety of surfaces to represent the different scenarios that could be encountered on the moon. Different grits of sandpaper can be attached to the slats to represent different surfaces.
4. With the protractor, make a scale to measure the height of the crater walls (inclined plain) in degrees.

The Force Test (Area 3)

The force that is exerted by the rover can be measured with a spring scale attached to a stationary eye-bolt mounted on the surface of the Lunar Testing Facility. Recording the amount of force exerted by the rover will help students evaluate their rover designs.

Materials

1. Platform made from wood, foam board, and cardboard
2. Eyebolts with nuts and washers (1/4 x 2 inches)
3. Packing tape or duct tape
4. Cord for the rover

Procedures

1. Cut out a platform from foam board that measures (40cm x 40cm)
2. Drill a hole in the middle of the platform for the eyebolt.
3. Cut out two strips of foam board (5cm x 40cm). Mount the strips along the edges of the platform to raise the platform to a height that will accommodate the bolt.
4. Mount the platform to a desk or table with packing tape or duct tape for security.

5. Attach the spring scale to the eye of the bolt.
6. Students can attach their rover to the bolt with a cord. The spring scale will measure the force of the rover against the scale.

The Sand Pit (Area 4)

The surface of the Lunar Testing facility can include an area covered with a layer of sand to represent the surface of the moon. The students can make observations to describe the way their rover performs in the sand pit and make adjustments in their rover designs.

Materials

1. Foam board
2. Exacto Knife
3. Steel Ruler
4. Pens and pencils
5. Packing tape
6. Sand

Procedures:

1. Cut the foam board with an exacto knife and a steel ruler. Measure out the foam board strips and score them with the knife and the ruler. Cut four foam board strips to measure 5cm wide and 40cm long. These strips will serve as the side of the box.
2. Cut the base of the box from the foam board. The sandbox base will measure 40cm x 40cm square.
3. Connect the strips to the base with packing tape to create a sand box.
4. Fill the box with enough sand for the student rovers.

Possible Data to Collect During Testing

The purpose of the Lunar Testing Facility is to test the student rovers in a simulated lunar environment for the classroom. There are four testing areas including a Lunar Test Track, Craters, the Force Test, and the Sand Pit. Within each of the testing areas, adjustable surfaces and adjustable heights of the inclined planes will serve as variables for the data collection. Students can collect, record, and display data describing the:

1. Amount of force exerted by the rover.
2. Speed, time and distance of various types of testing surfaces.
3. Angles to climb on the side of a crater.
4. Type of propulsion that would make the rover move two meters.
5. Type of payload that could be carried by the rover.
6. Adjustment of rover design to accommodate the data.

Technology

There are several technologies that are available for the students and their teachers to test and collect data. The commercially available data collection systems use probes to collect data such as speed, motion, and force that are accurate and measure in small increments. With the electronic measuring devises, data can be entered into a spreadsheet and analyzed for patterns.

Evaluation

The evaluation portion of this lesson will begin with a classroom discussion exploring the importance of extensive testing of the lunar equipment by NASA scientists and engineers before any hardware or astronauts are sent to the moon.

Classroom Discussion Questions:

1. Why is the collection of data important when testing a lunar rover?
2. Why is it important to collect data describing the forces and motions of rovers on the moon?
3. Why is it important that the Lunar Testing Facility model closely resemble the lunar environment?
4. Why should all of the student-designed rovers be tested on the same Lunar Testing Facility?
5. What is the best way to record the data from the Lunar Testing Facility?

Following the completion of the classroom discussion, the teacher could pass out the student handout: *Lunar Testing Facility: Solution Evaluation* for the students to complete.

Student Name_____ Date_____

Lunar Testing Facility: Construction Task

As we begin to explore the moon, lunar rovers will be an important part of the exploration. However, before a rover can be sent to the moon, NASA scientists and engineers will need to collect data describing the forces and motions exerted by the rover. The purpose of the Lunar Testing Facility is to test the rovers in a simulated lunar environment for the classroom. The testing facility would need to have the following characteristics:

1. A testing track with inter-changeable surfaces to measure speed, distance, and time.
2. A crater with adjustable sides (inclined plane) to determine the best angle the rover can safely climb.
3. A measurement devise to identify the force exerted by the rover as it travels over the simulated lunar surface.
4. A sand pit to test the student rovers' performance in simulated lunar soil.

Construction Task

Each student group will design and construct a Lunar Testing Facility that could be used to test the rover for the forces and motion exerted by the rover.

Student Name_____ Date_____

Lunar Testing Facility: Solution Evaluation

Answer the following questions:

1. What are the variables that could be tested with the Lunar Test Facility?

2. What materials would best represent the lunar surface?

3. Why is it important for the NASA scientists and engineers to complete an extensive testing program on the lunar rovers before they are sent to the moon?

4. Brainstorm a list of student-rover experiments that could be conducted with the Lunar Testing Facility.

5. Brainstorm a list of differences that may exist between the Lunar Testing Facility and the environment on the moon.

Write a description of the best design for a Lunar Testing Facility to test and measure the forces and motion of a student designed lunar rover.